

Distribution pattern of anchovy abundance and biomass in Division IXa from research surveys in 2007 and 2008

By

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ABSTRACT

A total of 4 acoustic surveys (3 Portuguese and 1 Spanish) rendering seasonal estimates of anchovy abundance, either for almost the whole Division IXa (spring and autumn Portuguese surveys) or only for the Subarea IXa South (Algarve + Gulf of Cadiz areas, early summer Spanish survey), were carried out during 2007 and the first half in 2008. In the November 2007 ICES WGACEEG meeting was presented - after detecting some computational errors - a corrected version of the estimates from the early summer 2007 Spanish survey previously provided to the September 2007 WGMHSA meeting. Anchovy total estimates from these surveys with indications of its general distribution patterns were as follow:

Portuguese surveys surveying almost the whole Division (except Subarea IXa North):

PELAGO07 (2007 Spr. Port. Surv.): **3247 million fish; 40.0 thousand tonnes**. Most of anchovy in Gulf of Cadiz. Present but relatively scarce in front of Lisbon.

SAR07NOV (2007 Aut. Port. Surv.): **1921 million fish; 24.8 thousand tonnes**. Most of anchovy in Gulf of Cadiz. Present but relatively scarce in front of Lisbon.

PELAGO08 (2008 Spr. Port. Surv.): **2353 million fish; 39.7 thousand tonnes**. Most of anchovy in Gulf of Cadiz. Present but relatively scarce in front of Lisbon and in northernmost coastal waters denoting a northernwards expansion of the population in the Division.

Spanish survey surveying the Subarea IXa South only:

ECOCÁDIZ 0707 (2007 Summ. Sp. Surv.): **1790 million fish; 28.9 thousand tonnes**. Anchovy all over the Gulf of Cadiz, also widely distributed through the Algarve, but mainly concentrated in the Spanish waters.

INTRODUCTION

The present working document compiltates the results on direct estimates of anchovy abundance and its distribution pattern throughout the Division IXa from reseach surveys conducted during the intersessional time between the September 2007 WGMHSA meeting (ICES, 2007 a) and the present June 2008 WGANC one. In the interim, a great part of this information was previously analysed and reported to the November 2007 WGACEEG meeting (ICES, 2007 b), including a corrected version of the 2007 Spanish acoustic survey (*ECOCÁDIZ 0707* survey) estimates provided previously to the 2007 WGMHSA meeting (see ICES 2007 a and Ramos *et al.*, 2007 a for the former version and ICES 2007 b and Ramos *et al.*, 2007 b for the corrected one).

As novel information provided to ICES after the WGACEGG meeting, the WD presents the results from two new Portuguese acoustic surveys carried out in November 2007 (*SAR07NOV*) and in April 2008 (*PELAGO08*).

The first anchovy DEPM Spanish survey in Subarea IXa South dates back to June 2005 (*BOCADEVA 0605*). A new DEPM survey (*BOCADEVA 0608*, 21 June - 4 July) will be carried out just after this year's WGANC meeting. Notwithstanding the above, information on the distribution pattern of anchovy egg densities is available from the CUFES sampling carried out in the *PELAGO07* and *ECOCÁDIZ 0707* acoustic surveys. No information is still available on the anchovy spawning season in 2008.

Since this year's exploratory assessment on anchovy in Subarea IXa South (Algarve + Gulf of Cadiz) specially benefits from recent direct estimates in 2007 and 2008, those estimates obtained in 2007, although already presented in different ICES WG, will be revisited again jointly with the new information in this WD for comparative purposes and description of recent trends.

Much of the text and graphical information used for the preparation of the present WD has been directly extracted with minor modifications from the information reported in the 2007 WGACEEG report.

MATERIAL AND METHODS

Three Portuguese and one Spanish acoustic surveys have been carried out during 2007 and the first half in 2008:

A) Portuguese IPIMAR surveys:

Research vessel: RV *Noruega*.

Sampled area: Atlantic-Iberian continental shelf waters of its EEZ and the waters belonging to the Spanish Gulf of Cadiz (ICES Subareas IXa Central-North, Central-South, and South).

Sampled depth range: 20 – 200 m.

Surveys:

- ***PELAGO07***: April 2007
- ***SAR07NOV***: November 2007
- ***PELAGO08***: April 2008

B) Spanish IEO surveys:

Research vessel: RV *Cornide de Saavedra*.

Sampled area: both Portuguese (i.e. Algarve area) and Spanish waters of the Gulf of Cadiz (ICES Subarea IXa South).

Sampled depth range: 20 – 200 m.

Surveys:

- ***ECOCÁDIZ 0707***: July 2007
- No conventional acoustic survey in July 2008. Ship time in July 2008 will be invested in an anchovy DEPM survey (***BOCADEVA 0608***).

All these surveys followed the standard methodology adopted by the Planning Group for Acoustic Surveys in ICES Subareas VIII and IX (ICES, 1986; 1998) and recommendations given by the WGACEGG (ICES, 2006 b,c). The methodological differences between these recent surveys are not considered by the WGACEGG members as important as to prevent from any comparison between their results, such differences being basically due to:

- The echo-sounder and working frequencies used (IPIMAR surveys: Simrad EK 500 working at 38 and 120 KHz; IEO survey since 2007 onwards: Simrad EK 60 working at 18, 38, 70, 120, and 200 KHz).

- The fishing gear used as sampler for echo-trace identification/confirmation and gathering biological data (IPIMAR surveys: bottom and pelagic trawl gears; IEO surveys: pelagic trawl).

- The software used for data storage and post-processing (IPIMAR surveys: Movies+ software; IEO surveys: SonarData EchoView software).

- The set of species-specific TS-length relationships: at present, the new IPIMAR spring survey series, *PELAGO*, takes into account the same agreed species-specific TS values than the IEO surveys, but for mackerel (b_{20} IPIMAR= – 82.0 vs b_{20} IEO= – 84.9).

Regarding their respective objectives, the SAR Portuguese November surveys, as presently planned, are mainly aimed at the mapping of the spatial distribution of sardine *Sardina pilchardus*, and anchovy *Engraulis encrasicolus*, and the provision of acoustic estimates of their abundance and biomass by length class and age groups, specially the computation of a sardine recruitment index (for the time being age-structured estimates are only available for sardine).

Although the main objective of the *ECOCÁDIZ* Spanish surveys was formerly the mapping and the size-based and age-structured acoustic assessment of the anchovy SSB, and hence the survey's dates, mapping and acoustic estimates of all of those species susceptible of being assessed (according to their occurrence frequency and abundance levels in fishing stations) are also obtained.

This same 'multi-species' or 'pelagic community' approach has also been adopted in the new *PELAGO* Spring Portuguese survey series, at least, for the time being, for the southern area (Subarea IXa South), which has involved a substantial increase in the number of fishing stations as compared with previous surveys.

In any case, the progressive inclusion of alternative (continuous and discrete) samplers for collecting ancillary information on the physical and biological environment (including top predators) are shaping these surveys as true 'pelagic ecosystem surveys'.

RESULTS AND DISCUSSION

1.- General distribution and species composition of the pelagic fish assemblages in Division IX: an overview of the results from the 2007 spring-summer acoustic surveys (after ICES, 2007 b).

Figure 1 shows the general distribution of the pelagic fish species in ICES Areas VIII and IX as inferred from their relative importance in survey trawls performed at the 2007 spring acoustic surveys of each institute (the IFREMER's *PELGAS07*, the IEO's *PELACUS 0407* and the IPIMAR's *PELAGO07*). Compared with other adjacent areas in the European Atlantic waters, the Bay of Biscay and the Atlantic waters of the Iberian Peninsula show high pelagic fish diversity. Anchovy and sardine showed in 2007 a different distribution, with sardine spreading through all the covered area (and beyond), while anchovy basically showed two local populations at the Bay of Biscay and the Gulf of Cadiz.

In the Portuguese Subareas IXa-CN and IXa-CS, because the *PELAGO07* survey is targeted on sardine, most of their fishing stations are located near shore, where the probability of finding sardine is higher (see **Figure 2** for more details). Thus, the fishing station reflects the fish pelagic community located close to the coast, which, in general is dominated by sardine. In the Subarea IXa-S a pelagic community approach was adopted for this survey with a higher number of trawls covering all the continental shelf, and then in this last subarea the pelagic community is reflected.

The Spanish and French acoustic surveys (including the early summer *ECOCÁDIZ 0707* Spanish survey in the Gulf of Cádiz), although having as target species sardine and/or anchovy, performed the hauls with the aim of detect all the pelagic species presented in the areas (to identify echotracés).

Anchovy and sardine are accompanied by other pelagic species like mackerel (*Scomber scombrus*), predominantly off the North Iberian coast and Bay of Biscay, horse mackerel (*Trachurus trachurus*), spread through the Iberian Peninsula, the Armorican shelf and beyond, a local population of sprat (*Sprattus sprattus*) in the Bay of Biscay, and other species like chub mackerel (*Scomber japonicus/colias*) abundant in the Gulf of Cadiz and south Portugal, bogue (*Boops boops*), blue jack mackerel (*Trachurus picturatus*) and boarfish (*Capros aper*). The rest of pelagic species less frequent in the catches have been reflected in the map as “others” and include: Mediterranean horse-mackerel (*Trachurus mediterraneus*), blue whiting (*Micromesistius potassou*), snipefish (*Macroramphosus scolopax*), sandeel (*Ammodytes tobianus*) and hake (*Merluccius merluccius*).

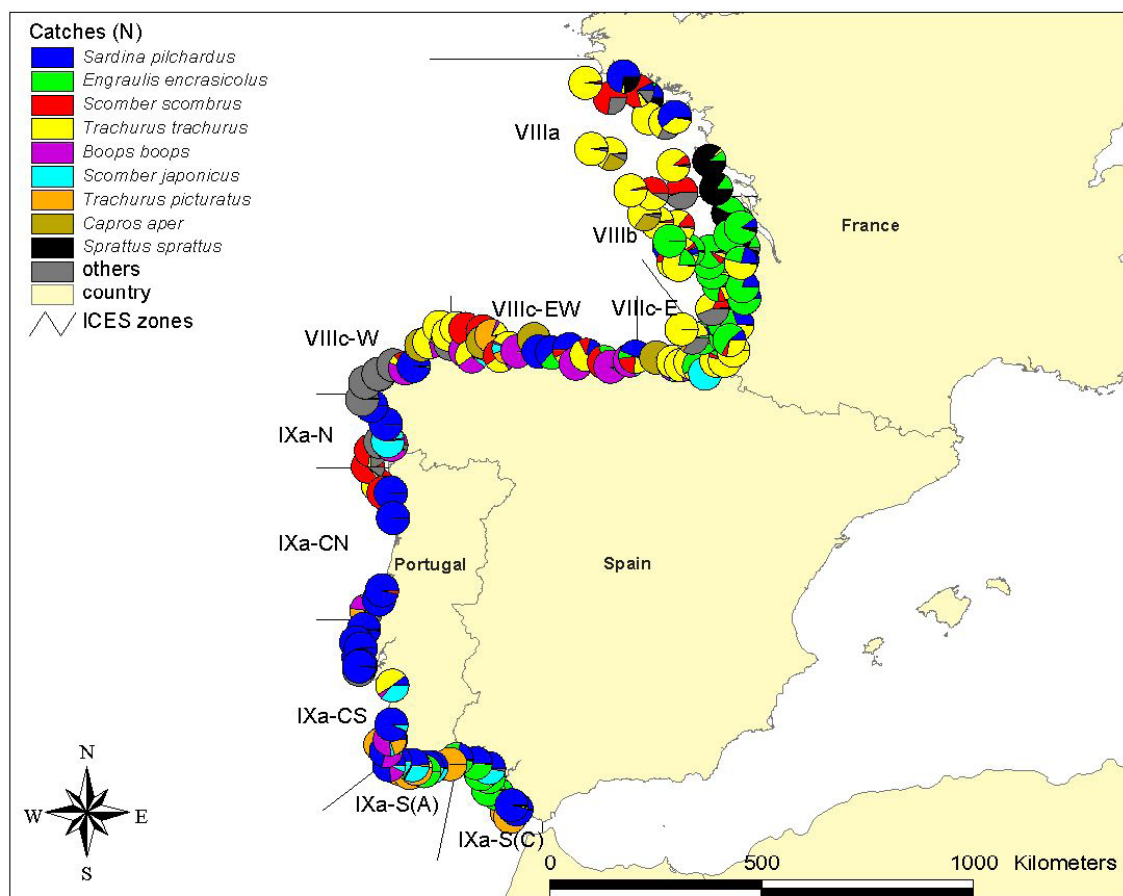


Figure 1. Species distribution (percentage in numbers in fishing stations) along the spring acoustic surveys in the Atlantic waters of the Iberian Peninsula and Armorican shelf (*PELGAS07*, *PELACUS 0407*, *PELAGO07* surveys; source: ICES, 2007 b).

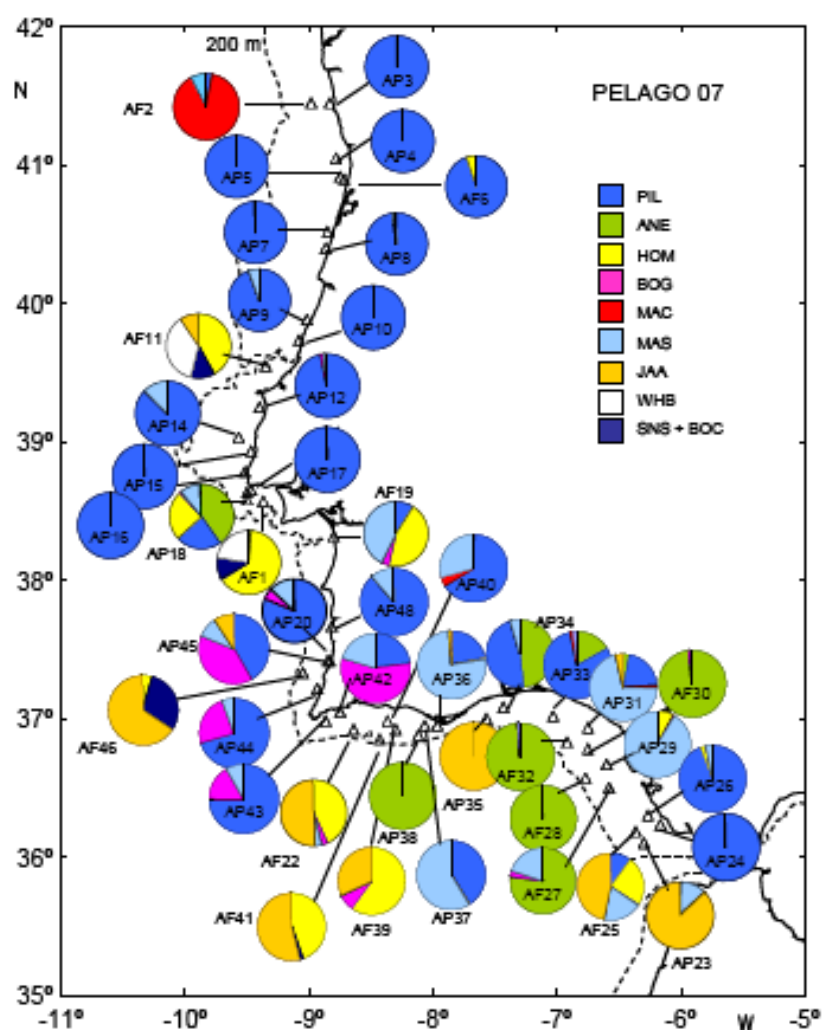


Figure 2. PELAGO07 spring Portuguese acoustic survey in Division IXa. Location of valid fishing stations and species composition (percentages in number. AP: pelagic trawl, AF: bottom trawl; source: ICES, 2007 b).

For the southernmost subarea in Division IX (Subarea IXa South), the *ECOCÁDIZ 0707* survey provides additional seasonal information on the pelagic fish assemblage in summer, which essentially maintains the same structure found some months before during the April Portuguese survey (**Figure 3**). Thus, from the set of more frequent species in the *ECOCÁDIZ 0707* survey stood especially out chub mackerel, followed by mackerel, bogue, anchovy, Mediterranean horse-mackerel, and sardine. The most abundant species in hauls were anchovy (52% of the total number), chub mackerel (23%), and sardine (20%). Blue jack-mackerel accounted for 3% in caught numbers, and the remaining species do not reach 1%. At first sight, some inferences on the species' distribution might be carried out from the combination of information from fishing hauls and the regional contributions to the total energy attributed to each species. So, sardine, round sardinella, *Sardinella aurita*, anchovy, horse mackerels species and mackerel seemed to show greater densities (or simply were only present) in the Spanish waters, whereas chub mackerel, blue jack-mackerel and bogue might be considered as typically "Portuguese species" in this survey.

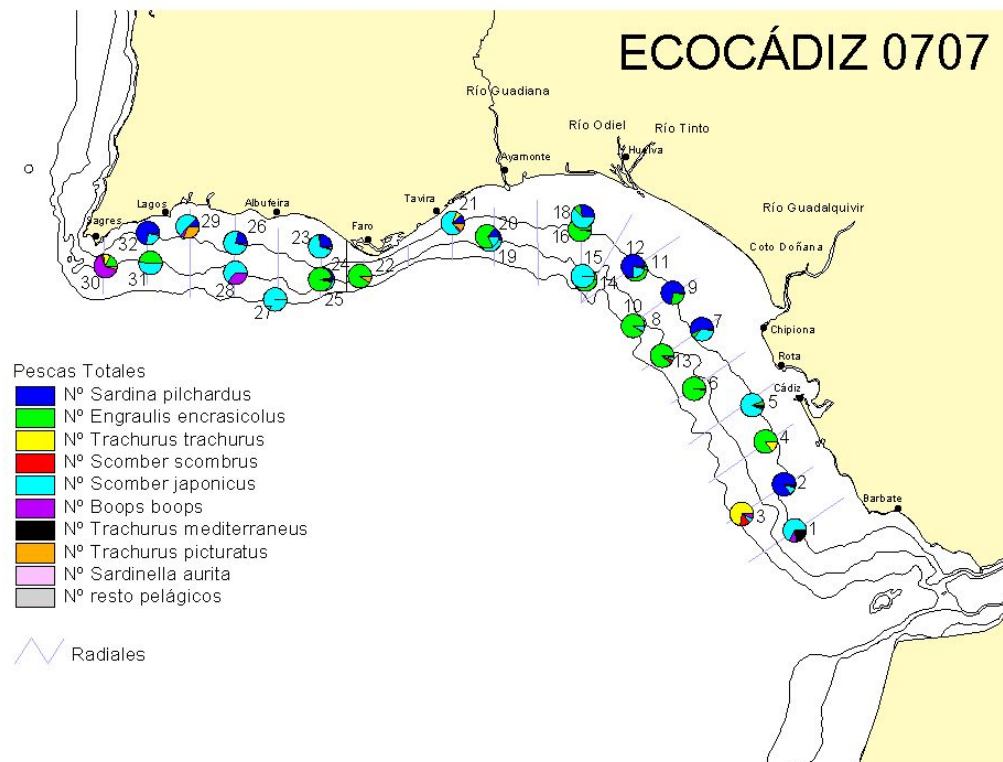


Figure 3. ECOCÁDIZ 0707 summer Spanish acoustic survey in Subarea IXa South. Location of valid fishing stations and species composition (percentages in number), (sources: Ramos *et al.*, 2007 b; ICES, 2007 b).

Unfortunately, this review on the spatio-temporal species composition of the European southern Atlantic pelagic fish assemblages has to be restricted to the 2007 spring and summer seasons, since data on this issue are not still available from IPIMAR neither for the 2007 November- nor 2008 April Portuguese surveys (SAR07NOV and PELAGO08).

2.- Anchovy distribution as inferred from the combined analysis of acoustic energy and egg densities (after ICES, 2007 b, and new data from IPIMAR).

2.1.- 2007 spring surveys.

Figure 4 shows for comparative purposes the acoustic energy in sA (m^2/mn^2 ; NASC, Nautical Area Scattering Coefficient) allocated to anchovy during the 2007 spring acoustic surveys carried out by the IPIMAR (April), IEO (April) and IFREMER (May) in their respective areas. The higher integration values (red and green dots) for this species were located in the Bay of Biscay (France), principally in Subarea VIIIb, and in the Gulf of Cadiz (Division IXa), principally in Subarea IXa-S(C) (Spain). In the Cantabrian Sea, density was scarce, although a little bit higher than in 2006 (ICES, 2007 a). In front of Lisbon (Portugal), between Cascais and Cabo Raso, a small density of anchovy was also detected in 2007. Values were practically null in the rest of the prospected area. Null values (black points) also describe the tracks performed in every survey. In the Bay of Biscay (Subarea VIII) a gap could be observed in the data (no data) due to bad weather conditions during the survey. Values higher than $1000 \text{ m}^2/\text{mn}^2$ are located in the Gulf of Cadiz (maximum of 1800) and in the Bay of Biscay (maximum of $1559 \text{ m}^2/\text{mn}^2$), (ICES, 2007 b).

The results on anchovy egg densities, from CUFES, for the above three acoustic surveys covering the whole region from Gibraltar to Brest, are presented in **Figure 5**. The 2007 surveys showed the highest numbers recorded for anchovy eggs from CUFES in spring time. The highest egg abundances were observed, as expected, in NE Bay of Biscay, overlapping with the adult distribution, as well as in the Gulf of Cádiz, coinciding with the region of high acoustic energy from anchovy in the south (see **Figure 4**). Contrasting with previous surveys it is noticeable the occurrence of eggs almost all along the Portuguese coast with a peak of abundance off the mouths of the rivers Sado and Tejo. Adult anchovy were observed in this region and in eastern Algarve. The area around the NW corner of the Peninsula was void of anchovy eggs.

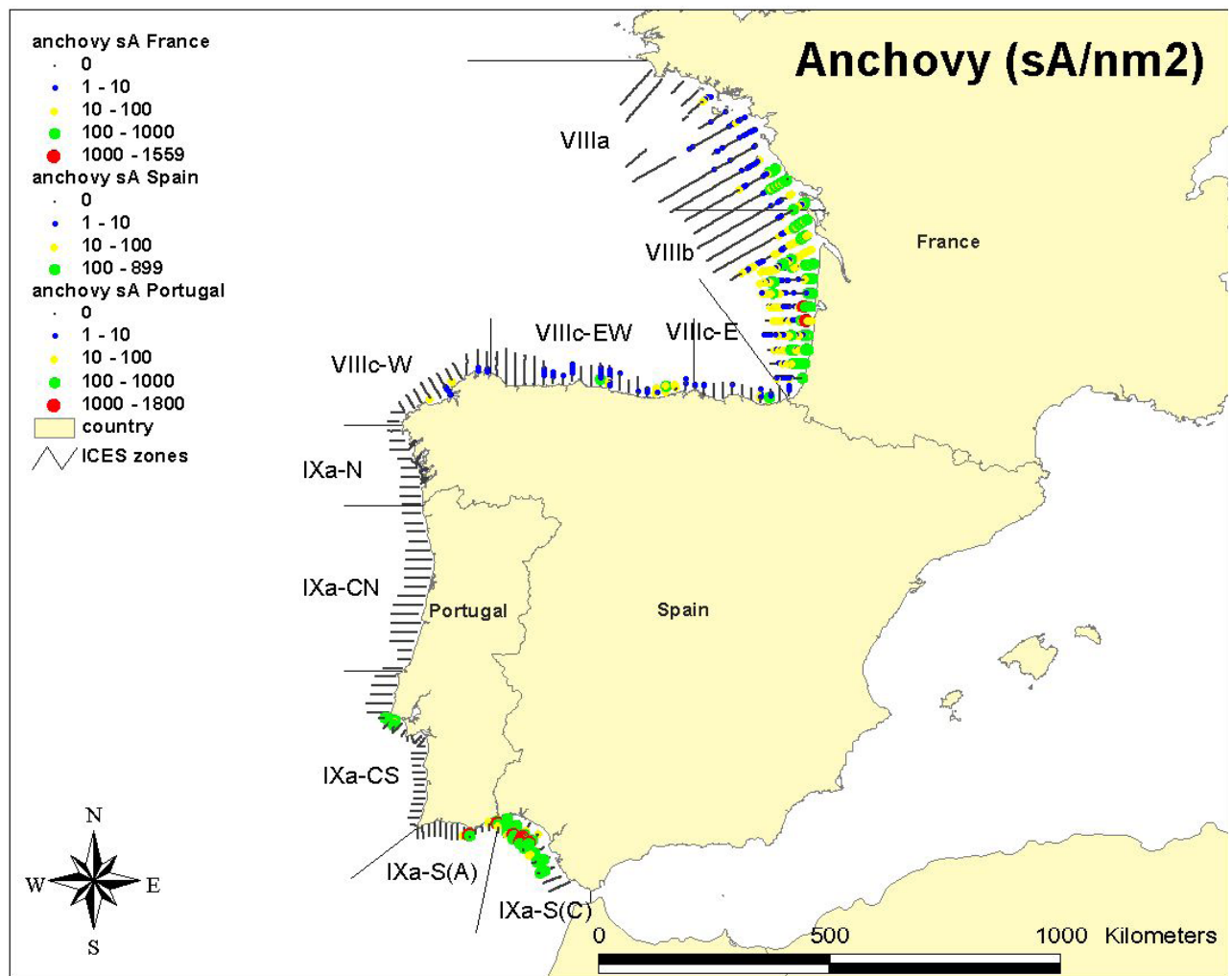


Figure 4. Acoustic energy allocated to anchovy in the 2007 spring combined coverage of the Atlantic Iberian Peninsula and Armorican shelf (source: ICES, 2007 b).

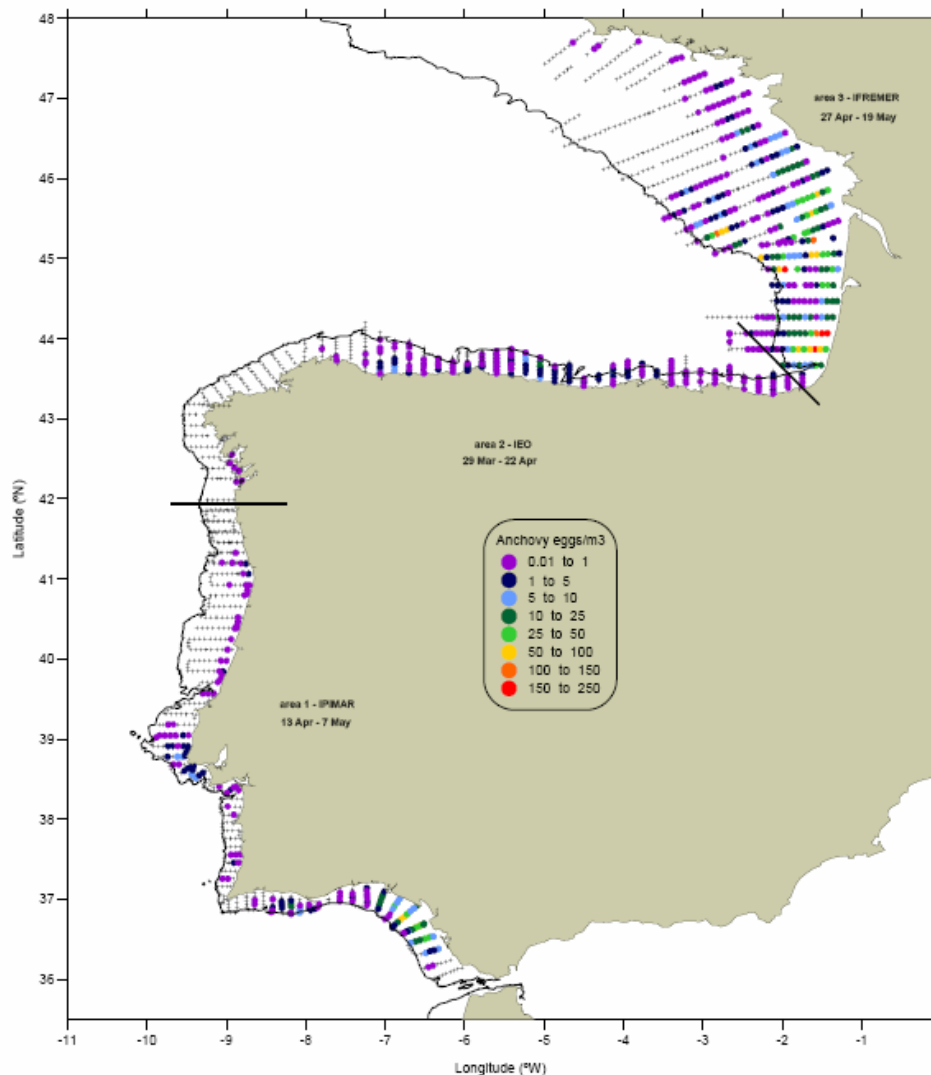


Figure 5. Anchovy egg distribution from CUFES sampling during the 2007 spring acoustic surveys carried out by IFREMER (*PELGAS07*), IEO (*PELACUS 0407*) and IPIMAR (*PELAGO07*), (source: ICES, 2007 b).

2.2.- 2007 early summer survey (only Subarea IXa South).

The *ECOCÁDIZ 0707* was carried out in the Subarea IXa South from 3 – 12 July 2007. Although anchovy occurred almost all over the shelf of the sampled area, the species still was mainly distributed in the Spanish waters off the Gulf of Cadiz (23 – 160 m depth), with the highest densities occurring in the central part of the sampled area, mainly between 40 and 115 m depth. Two additional nuclei of high density were recorded in front the Bay of Cadiz between 30 and 100 m depth, and in front of the Coto de Doñana coast between 40 and 80 m depth. In this last area were also recorded the highest densities of anchovy eggs, although in shallower waters than 40 m depth. Unlike the spatial pattern observed in April, the species was widely distributed (20– 220 m) in the Portuguese waters but in low densities, except in the area comprised between Albufeira and Cabo Santa María between 70 and 170 m depth, where, surprisingly, the highest sA values attributed to the species in the survey were recorded (**Figure 6**).

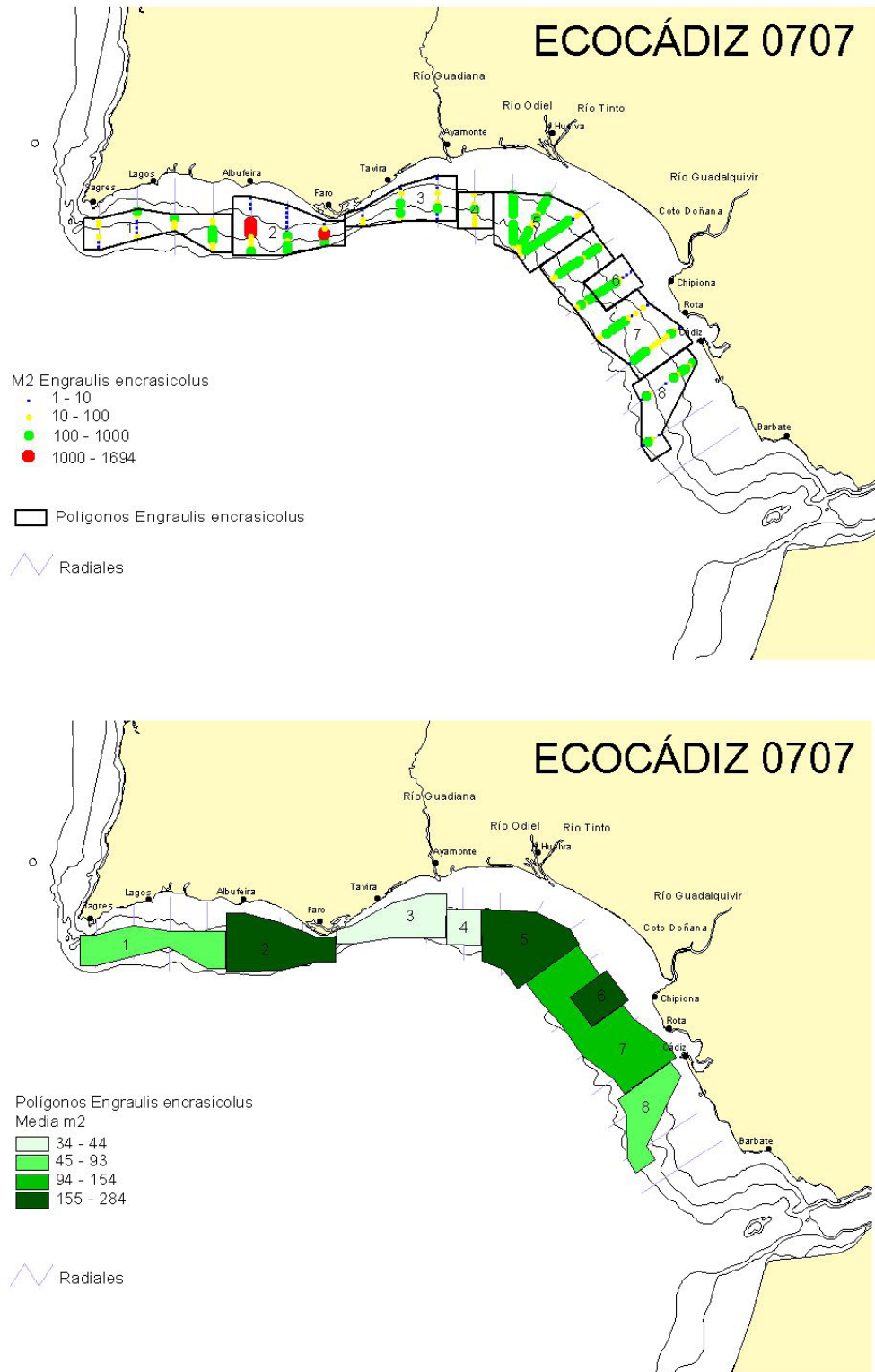


Figure 6. *ECOCÁDIZ 0707* summer Spanish acoustic survey in Subarea IXa South. Distribution of the NASC coefficients (m^2/mn^2) attributed to anchovy. Homogeneous size-based post-strata used in the abundance/biomass estimates are also shown. Top: NASC values by EDSU. Circle diameter and colour scale proportional to the acoustic energy. Bottom: strata coloured according to their average NASC values (source: ICES, 2007 b).

A further seasonal comparison of the distribution of anchovy egg densities in Subarea IXa South is possible from CUFES data from the Portuguese *PELAGO07* and the Spanish *ECOCÁDIZ 0707* acoustic surveys (**Figure 7**). The first survey took place at the beginning of the spawning season for the species in the area. Nevertheless, as stated before, the number of stations with eggs and the values of density were considerable, and higher than in previous spring surveys. In early July the anchovy egg densities were even higher than in May and reached peak values within the series of records for this region. The area of higher abundance was, in both surveys, between Cádiz and Huelva (coinciding with the region with higher acoustic energy for anchovy) but virtually the whole region from Gibraltar to Cape S. Vicente was occupied with anchovy eggs; the exceptions were the eastern and western limits during the Portuguese spring survey. No information on anchovy eggs is still available from the *PELAGO08* survey.

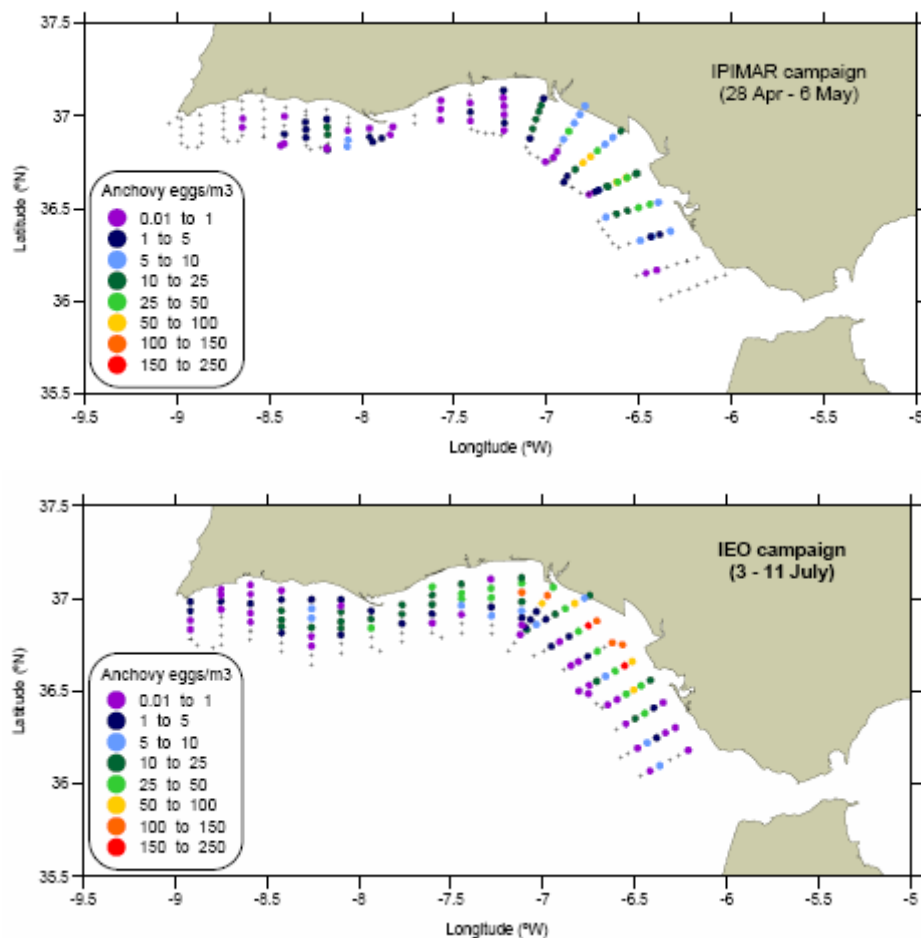


Figure 7. Anchovy egg distribution in Subarea IXa South from CUFES sampling during the 2007 spring Portuguese acoustic survey (*PELAGO07*, upper panel) and early summer Spanish acoustic survey (*ECOCÁDIZ 0707*, lower panel), (source: ICES, 2007 b).

2.3.- 2007 autumn survey.

The autumn Portuguese *SAR07NOV* acoustic survey was conducted between 24 October and 17 November 2007, with the main objective of observing and estimating the sardine recruitment to the fishery. Ship time limitations prevented from surveying the whole survey area, the acoustic sampling being restricted to those areas where sardine recruitment is more frequently observed. This decision led to the western coast from the south of Cabo Espichel southwards and the southwestern Algarvian coast till Albufeira were not sampled. Conversely, the sampling intensity by fishing stations was

increased, as happened in the *PELAGO07*, in the Subarea IXa South with the aim to obtain a better understanding of the pelagic fish assemblages in an area characterised by a high species diversity. CUFES sampling was carried out during the survey but information of anchovy egg densities, if they occurred, is still not available.

As described in previous autumn (and spring-summer) surveys anchovy mainly occurred in the fishing stations carried out in the Gulf of Cadiz area, mainly in the Spanish waters, and in a lesser quantity along the Lisbon coast, between Cascais and Cabo Raso (**Figure 8**).

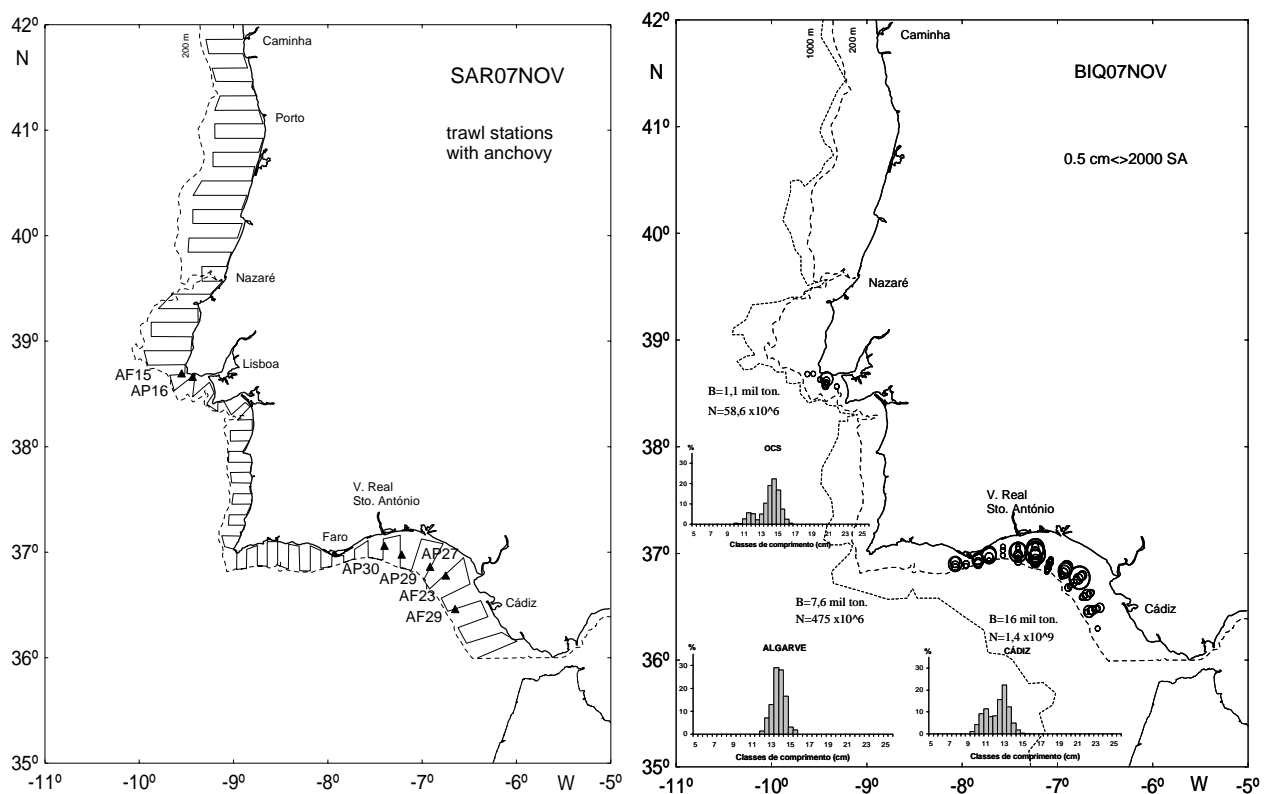


Figure 8. SAR07NOV autumn Portuguese acoustic survey in Division IXa. Anchovy positive fishing stations (left panel) and distribution of the NASC coefficients (m^2/mn^2) attributed to the species (right panel). Acoustic estimates and size composition of the estimated populations by subareas will be presented in the section 3 (source: Vitor Marques, IPIMAR, pers. comm.).

2.4.- 2008 spring surveys.

During the preparation of the present WD the only information available from research surveys on anchovy in Division IXa is the one from the spring Portuguese acoustic survey, *PELAGO08*. The survey was carried out between mid April-early May and found out anchovy concentrations - apart from the ones usually occurring in front of Lisbon (north of the Subarea IXa-CS), eastern Algarve (east of the IXa-S(A)) and Gulf of Cadiz (IXa-S(C)) - in front of Porto and Figueira da Foz, in the Subarea IXa-CN (**Figure 9**). Such observations indicate a more spread northernwards distribution than the observed one in recent years. As usual, the highest records of acoustic energy attributed to the species were again observed in the Spanish part of the Gulf of Cadiz (IXa-S(C)).

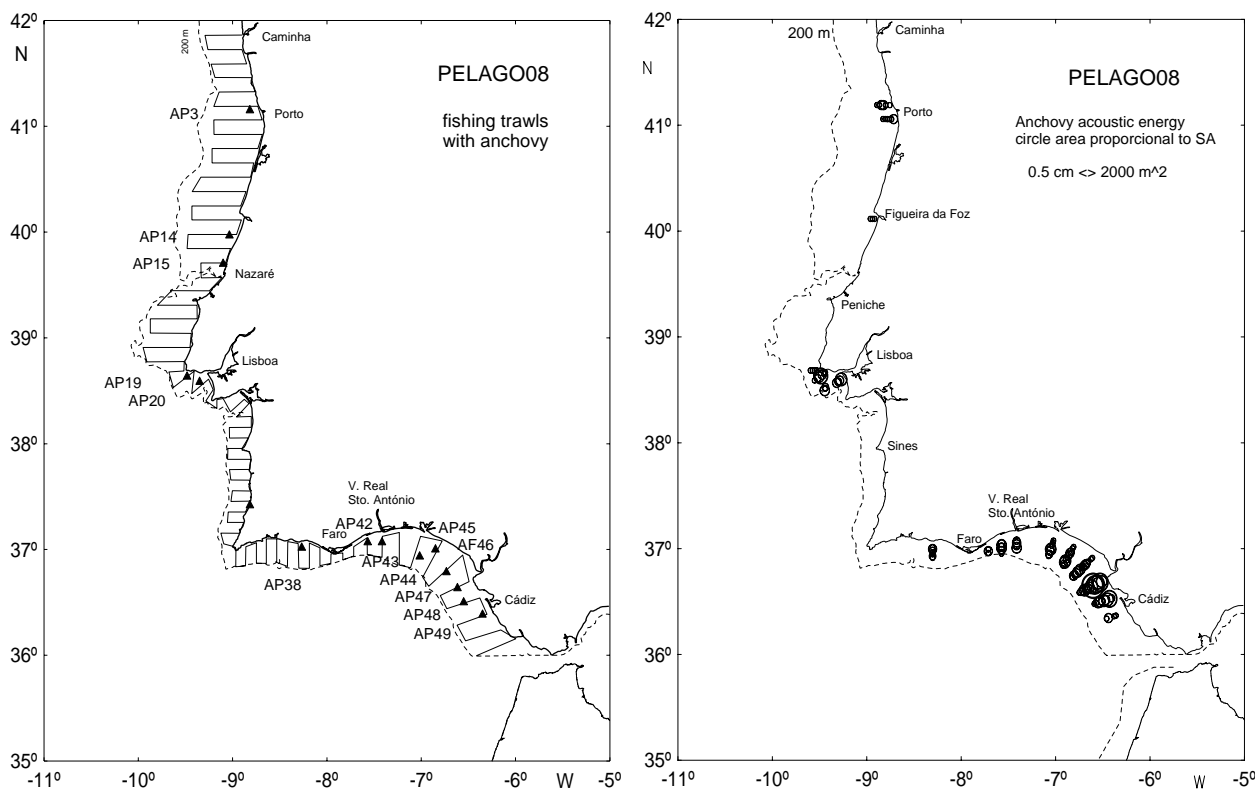


Figure 9. *PELAGO08* spring Portuguese acoustic survey in Division IXa. Anchovy positive fishing stations (left panel) and distribution of the NASC coefficients (m^2/mn^2) attributed to the species (right panel), (source: Vitor Marques, IPIMAR, pers. comm.).

3.- Acoustic estimates of anchovy abundance and biomass and its population structure in Division IXa.

3.1.- 2007 spring survey.

The anchovy total biomass estimated during the *PELAGO07* survey for the whole Division IXa was 40 thousand tonnes (3,247 million fish), which represents a 42.3% increase in relation to the average value for the entire time series (28.1 thousand tonnes), and it was almost entirely located in the Subarea IXa South (96.8%, i.e. 3,144 millions, and 95.1%, i.e. 38 thousand tonnes, of the total estimated abundance and biomass in the whole Division, respectively). As in previous years, the area with the highest anchovy abundance and biomass was the Spanish waters off the Gulf of Cadiz (Subarea IXa-S(C), 33.4 thousand tonnes, 2,860 million fish), accounting for 88% and 84% of the total estimated abundance and biomass (**Figure 10**). The Portuguese coast presented an anchovy distribution pattern similar to the one described in previous years, with a low occurrence in front of Lisbon (between Cascais and Cabo Raso, 1.9 thousand tonnes and 103 million fish), and a somewhat denser concentrations in the Algarve (between Faro and the Guadiana river mouth, 4.6 thousand tonnes, 284 million fish).

The anchovy length composition showed a spatial gradient, with the modes of the size distributions increasing from the Spanish waters of the Gulf of Cadiz (12 cm), through Algarve (13 cm), to the Cascais area (14 cm), (**Figure 11**).

3.2.- 2007 early summer survey (only Subarea IXa South).

Anchovy total biomass in the Subarea IXa South was estimated during the *ECOCÁDIZ 0707* survey at 28.9 thousand tonnes (1,790 million fish), values somewhat lower when compared to the 38.0 thousand tonnes estimated shortly before in the Portuguese survey. The Spanish Gulf of Cadiz contributed with the 60% (17.2 thousand tonnes) of the total biomass and 69% of the total abundance (1,232 million fish), (**Figure 10**). As usual, size- and age-based estimates still suggested a westward increasing size (-age) gradient, with the largest (and oldest) anchovies being more abundant in the westernmost limit of their distribution, and a recruitment area located in shallow waters close to the Guadalquivir river (**Figure 11**, **Figure 13**).

3.3.- 2007 autumn survey.

Total anchovy abundance and biomass estimated during the SAR07NOV survey were estimated at 1,921 million fish and 24.8 thousand tonnes. It should be noted that these estimates don't correspond to total estimates for the sampled area usually surveyed in the Portuguese surveys since about two thirds of the Subarea IXa-CS and about the half of the Subarea IXa-S(A) were not acoustically sampled. Nevertheless, anchovy in the Spanish waters of the Gulf of Cadiz (Subarea IXa-S(C)) was abundant, with estimated abundance and biomass of 1,386 millions and 16.1 thousand tonnes. In the Algarve (Subarea IXa-S(A)) were estimated 475 million fish and 7.6 thousand tonnes. In the western coast, between Cascais and Cabo Raso (Subarea IXa-CS), the species only recorded 58.6 millions and 1.1 thousand tonnes (**Figure 10**).

Bimodal size compositions for the anchovy population in the Cascais-Cabo Raso area and the Spanish part of the Gulf of Cadiz denoted the possible occurrence in such areas of recruitment areas. So, their respective histograms were featured by a smaller modal class either at 11 cm (Cádiz) or 11.5 cm (Lisbon), and a larger one either at 13 cm (Cádiz) or 14.5 cm (Lisbon). Anchovy size composition in the Algarve area showed only one mode at 13 cm. (**Figure 11**)

3.4.- 2008 spring surveys.

The anchovy total biomass estimated during the *PELAGO08* survey for the whole Division IXa was 39.7 thousand tonnes (2,353 million fish), a biomass level almost identical to the one recorded the previous year, but coupled to a slight diminution in abundance, which suggests the occurrence of a population composed by larger fish. Anchovy was mostly concentrated, as usual, in the Spanish Gulf of Cadiz (Subarea IXa-S(C)), accounting for 77% (1,819 millions) and 74% (29.5 thousand tonnes) of the total estimated abundance and biomass in the Division, respectively. The Algarve (Subarea IXa-S(A)) yielded 4.7 thousand tonnes (212 millions), the Subarea IXa-CS (concentrated only in the Cascais-Cabo Raso area) 2.5 thousand tonnes (252 millions), and the Subarea IXa-CN (only two spots at Porto and Figueira da Foz) 3.0 thousand tonnes (69 millions), (**Figure 10**).

The anchovy length composition along the Division showed a general southward decreasing size gradient. So, the size histogram from the population in the Subarea IXa-CN showed two modes, the smaller one at 12 cm and the most important and larger at 17.5 cm. In the IXa-CS anchovy presented two well marked modes, the first and stronger one placed at 9 cm, indicating the occurrence of an important and late recruitment event in the population, and a larger secondary mode at 15 cm with a lower relative importance. Gulf of Cadiz anchovy population (IXa-S) was featured by a mixed size composition, with a clearly defined mode at 13 cm and secondary modes at 11 and 15 cm (**Figure 12**).

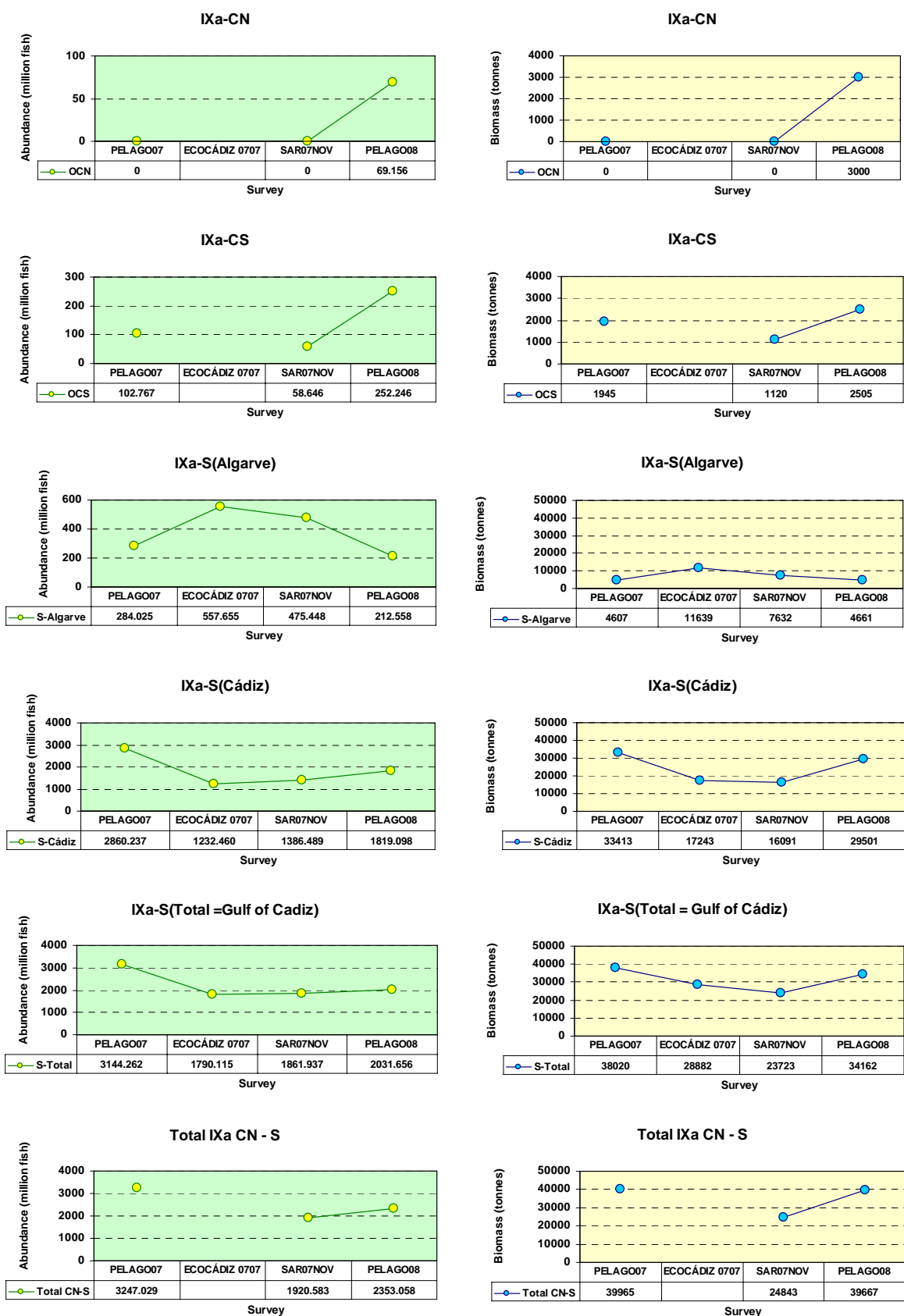


Figure 10. Recent trends (2007 and first half 2008) in acoustic estimates of anchovy abundance (million fish) and biomass (tonnes) in the Division IXa. Note the different scale on the y-axis (source: ICES, 2007 b and Vitor Marques, IPIMAR; pers. comm.).

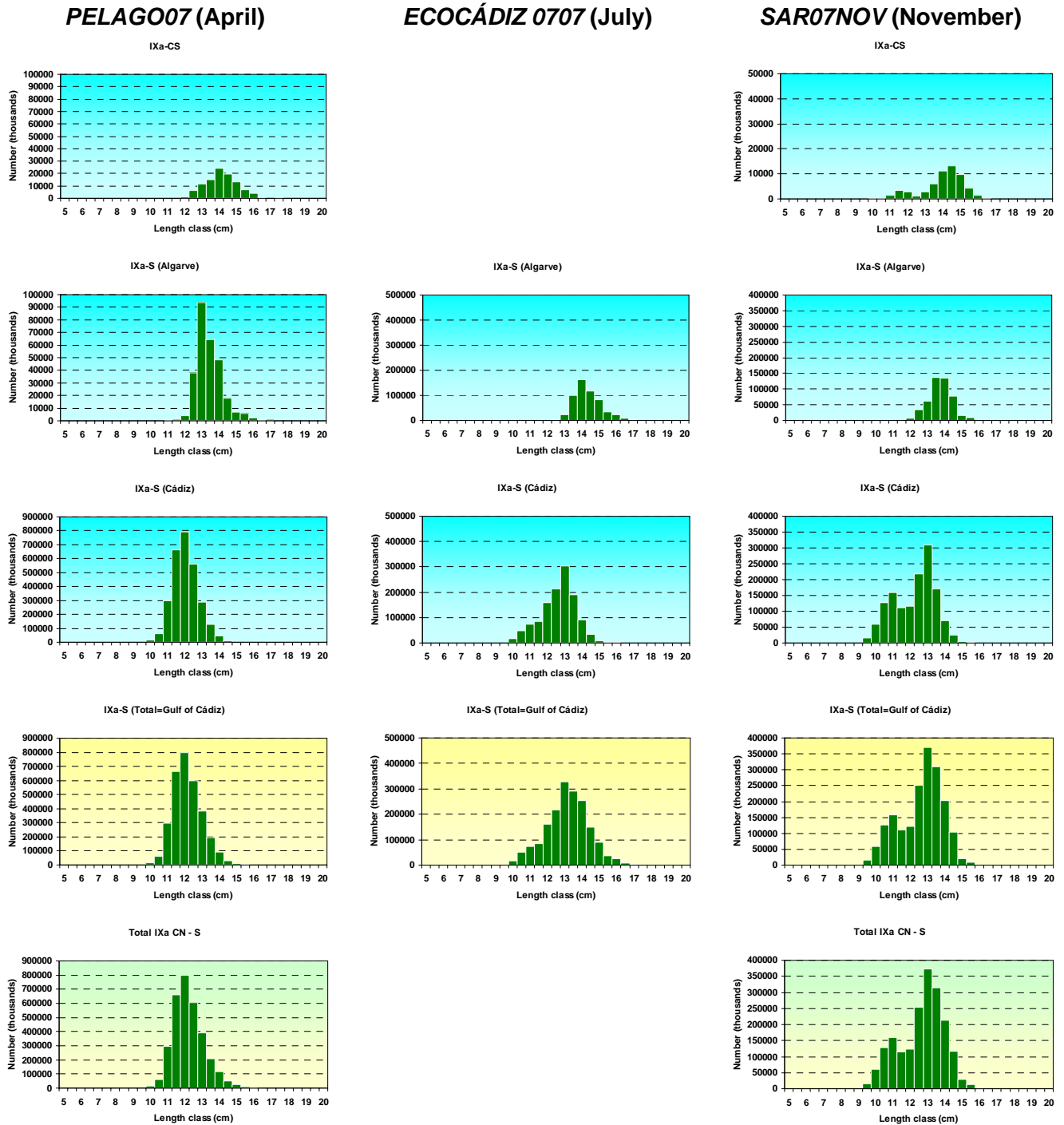


Figure 11. Estimated abundances by size class in the 2007 acoustic surveys. Note both the different scales in the y-axis depending on the Subarea and survey and the two last rows showing respectively subtotals for the entire Subarea IXa-S (=Algarve + Cádiz areas) and totals for the whole sampled area in the Portuguese surveys (from Subarea IXa-CN to Subarea IXa-S), (source: ICES, 2007 b and Vitor Marques, IPIMAR, pers. comm.)

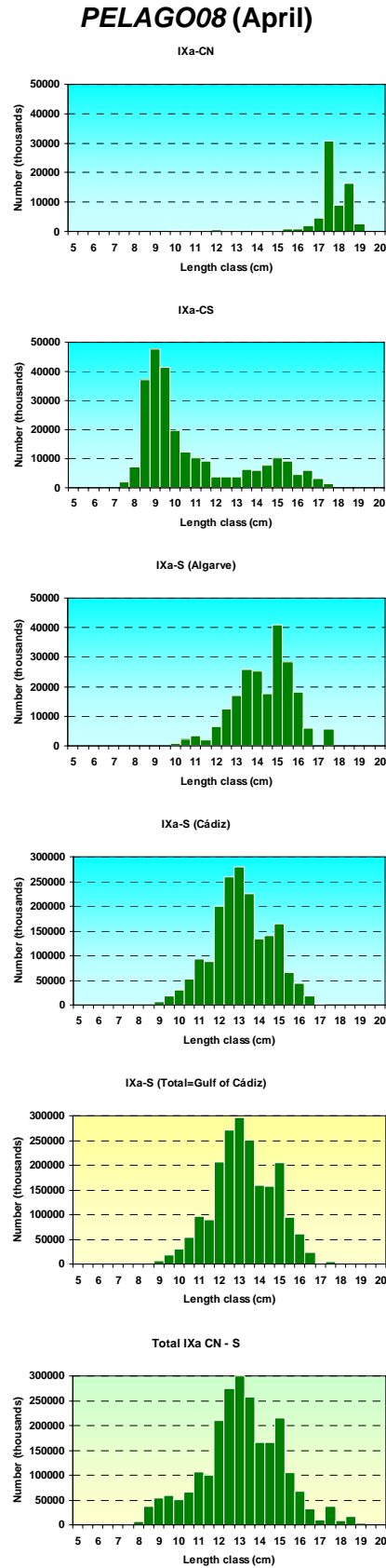


Figure 12. Estimated abundances by size class in the spring 2008 Portuguese acoustic survey, *PELAGO08*. Note both the different scales in the y-axis depending on the Subarea and the two last rows showing respectively subtotals for the entire Subarea IXa-S (=Algarve + Cádiz areas) and totals for the whole sampled area in the Portuguese surveys (from Subarea IXa-CN to Subarea IXa-S), (source: Vitor Marques, pers. comm.).

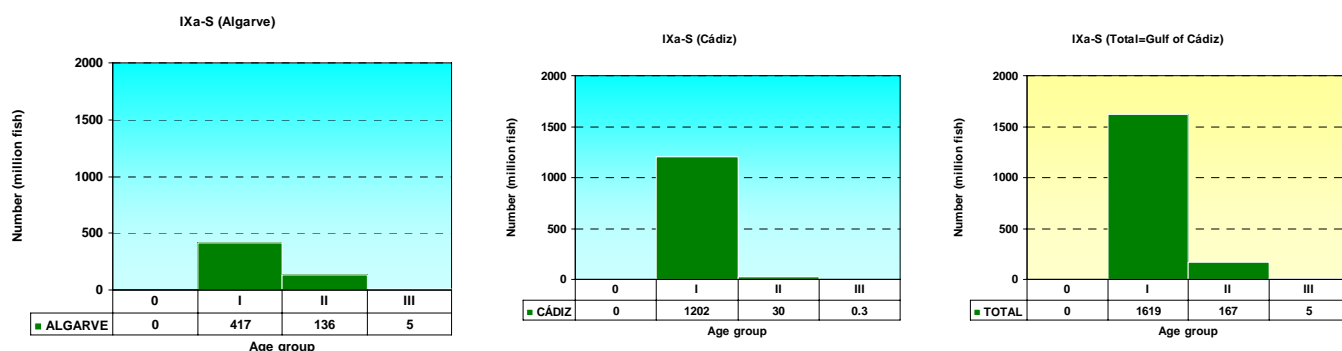


Figure 13. Estimated abundances by age group in the early summer 2007 Spanish acoustic survey, *ECOCÁDIZ 0707* (source: ICES, 2007 b).

4.- Time series of acoustic estimates.

The historical series of total and regional acoustic estimates of anchovy abundance (millions) and biomass (tonnes) either from the whole Division IXa (Portuguese surveys) or from the Subarea IXa South only (Spanish surveys) are shown in **Table 1** and **Figures 14, 15** and **16**. The estimates from the 2006 Spanish survey have been re-calculated under the “multi-species approach” and the WGACEEG recommended TS value set. Such estimates, therefore, differ from those ones previously reported either to WGMHSA or WGACEEG. Something similar also happens with the estimates from the 2004 Spanish survey (in this WD the estimates derived from using the accepted TS (b20) value of -72.6 dB instead of the formerly used of -71.2 dB is included) although these last estimates are pending of a further revision.

Table 1. Historical series of overall and regional acoustic estimates of anchovy abundance (millions) and biomass (tonnes) in Division IXa from Portuguese (*SAR-PELAGOS* series, upper pannel) and Spanish surveys (*ECOCÁDIZ* series, lower pannel).

| Portuguese survey | Estimate | Portugal | | | | Spain | | TOTAL | Sampled depth range | b ₂₀ Anchovy |
|-------------------|----------|----------|------|------|-------|----------|----------|----------|---------------------|-------------------------|
| | | C-N | C-S | S(A) | Total | S(C) | S(Total) | | | |
| Nov. 1998 | Number | 30 | 122 | 50 | 203 | 2346 | 2396 | 2549 | 20-200 m | -71.2 |
| | Biomass | 313 | 1951 | 603 | 2867 | 30092 | 30695 | 32959 | | |
| Mar. 1999 | Number | 22 | 15 | * | 37 | 2079 | 2079 | 2116 | | |
| | Biomass | 190 | 406 | * | 596 | 24763 | 24763 | 25359 | | |
| Nov. 2000 | Number | 4 | 20 | * | 23 | 4970 | 4970 | 4994 | | |
| | Biomass | 98 | 241 | * | 339 | 33909 | 33909 | 34248 | | |
| Mar. 2001 | Number | 25 | 13 | 285 | 324 | 2415 | 2700 | 2738 | | |
| | Biomass | 281 | 87 | 2561 | 2929 | 22352 | 24913 | 25281 | | |
| Nov. 2001 | Number | 35 | 94 | - | 129 | 3322 | 3322 | 3451 | | |
| | Biomass | 1028 | 2276 | - | 3304 | 25578 | 25578 | 28882 | | |
| Mar. 2002 | Number | 22 | 156 | 92 | 270 | 3731 ** | 3823 ** | 4001 ** | | |
| | Biomass | 472 | 1070 | 1706 | 3248 | 19629 ** | 21335 ** | 22877 ** | | |
| Feb. 2003 | Number | 0 | 14 | * | 14 | 2314 | 2314 | 2328 | | |
| | Biomass | 0 | 112 | * | 112 | 24565 | 24565 | 24677 | | |
| April 2005 | Number | - | 59 | - | 59 | 1306 | 1306 | 1364 | | |
| | Biomass | - | 1062 | - | 1062 | 14041 | 14041 | 15103 | | |
| April 2006 | Number | - | - | 319 | 319 | 1928 | 2246 | 2246 | | |
| | Biomass | - | - | 4490 | 4490 | 19592 | 24082 | 24082 | | |
| April 2007 | Number | 0 | 103 | 284 | 387 | 2860 | 3144 | 3247 | -72.6 | |
| | Biomass | 0 | 1945 | 4607 | 6552 | 33413 | 38020 | 39965 | | |
| Nov. 2007 | Number | 0 | 59 | 475 | 534 | 1386 | 1862 | 1921 | | |
| | Biomass | 0 | 1120 | 7632 | 8752 | 16091 | 23723 | 24843 | | |
| April 2008 | Number | 69 | 252 | 213 | 534 | 1819 | 2032 | 2353 | | |
| | Biomass | 3000 | 2505 | 4661 | 10166 | 29501 | 34162 | 39667 | | |

* Due to the distribution observed during the survey, the last transect (near the border with Spain) that normally belongs to the Algarve sub-area was included in Cadiz. ** Corrected estimates after detection of errors in the SA values attributed to the Cadiz area (Marques & Morais, 2003).

| Spanish Surveys | Estimate | Portugal: Algarve | Spain: Gulf of Cadiz | IXa South | Sampled depth range | b ₂₀ Anchovy |
|-----------------|----------|-------------------|----------------------|-----------|---------------------|-------------------------|
| June 2004 * | Number | 125 | 1109 | 1235 | 30-200 m | -72.6 |
| | Biomass | 2474 | 15703 | 18177 | | |
| June 2006 | Number | 363 | 2801 | 3163 | 20-200 m | |
| | Biomass | 6477 | 30043 | 36521 | | |
| July 2007 | Number | 558 | 1232 | 1790 | | |
| | Biomass | 11639 | 17243 | 28882 | | |

* Possible underestimation due to the shallow waters between 20 and 30 m depth were not acoustically sampled. Moreover, 2004 estimates are pending of revision (application of recent IEO standards in the estimation process: delimitation of post-strata, increased number of assessed species, species-specific TS, etc).

The estimates from those surveys covering the whole southernmost subarea (the IXa South, whose population is explored by an analytical assessment) show through the series that either the bulk (about or higher than 90% of both the total abundance and biomass) or even the whole of the anchovy population is concentrated in the Spanish waters of the Gulf of Cadiz.

The series show several gaps (mainly the Autumn Portuguese one) which makes difficult to follow any clear trend. Biomass estimates from 1998 to 2003 in this Subdivision have oscillated between 21 and 34 thousand tonnes. However, available estimates in 2004 and 2005 have decreased down to 18–14 thousand tonnes, evidencing a possible decline in the (spawning) population levels. In the 2005 WGMHSA and WGACEEG meetings was warned that the picture of an alarming decreasing trend just in 2004–2005 should be initially considered with caution for several causes. Firstly, the estimates themselves in such years seemed to be affected by problems related either to the sampling coverage of shallow waters (2004 Spanish survey, Ramos *et al.*, 2004; ICES, 2006 b) or to the echo-traces discrimination between fish and plankton (2005 Portuguese survey, Marques *et al.*, 2005; ICES, 2006 b). Secondly, the survey season for the Spanish surveys (late spring-early summer) entailed a 2–3 months delay relative to the usual March (since 2005 in April) Portuguese survey series which involves an additional mortality affecting the population estimates and a probable different population structure. Despite these facts a decline in the spawning population in 2005 was corroborated by two different direct sources, the Spring Portuguese acoustic survey and the Spanish DEPM one, which both yielded an estimated SSB at 14 thousand tonnes.

Notwithstanding the above, the 2005-2008 Portuguese spring survey seasons were coincident and their estimates, therefore, comparable, and they indicate an evident recovered population in 2006 and 2007-2008 up to a level close (2006) or even somewhat higher (2007, 2008) to the average estimate in the (Portuguese) historical series. The high 2006 estimate from the Spanish survey reinforces the above statement on a population recovery that year in the subdivision. However, the inter-annual trend depicted by the 2006 and 2007 Portuguese surveys is much more marked (an increase of about 14 thousand tonnes in 2007 and then a slight decrease of 4 thousand tonnes in 2008) than the trend exhibited by its Spanish counterparts (a 7.6 thousand tonnes decrease). Furthermore, the increased value in the 2007 population numbers, as estimated by the Portuguese survey, was in disagreement with the opposite trend observed from the Spanish surveys. What happened that year for such differences is a matter of concern and some working hypothesis were drawn in the last year's WGACEEG for explaining the above differences.

A wider distribution for anchovy along the subdivision is only recorded in some years of the time series. However, the lack of correspondence between this species' spreading and both the survey season and the magnitude of the resulting estimates suggests that such increases in the occupied area by the species should be driven by other factors than seasonal and/or density-dependence related ones (Ramos *et al.*, 2005). From the spatial patterns exhibited during the summer surveys in 2006 and 2007 by small and mid-sized pelagic fishes in the Subarea IXa-S, Ramos *et al.* (2007 b) suggested that the spatial dynamics of anchovy abundance and biomass (and probably sardine as well) in summer may be controlled in recent years in this area by a combination of local environmental forcing and a competitive exclusion or top-down (predation) mechanisms driven by mid-sized pelagic fish foraging (mainly by the chub mackerel, *Scomber japonicus*, acting alone or in combination with blue jack mackerel, *Trachurus picturatus*, and other *Trachurus* species) (see, for example, Quiñones *et al.*, 1997; Bertrand *et al.*, 2004, 2006). Other evidences from other direct sources quoted by the authors demonstrated, at least for anchovy, that the species exhibited in summer 2007 some local displacements to shallower areas, not covered by any survey, which may be one of the possible causes for the unexpected differences found in the estimates from relatively consecutive surveys.

All of these facts strengthen the necessity of an extended sampling coverage to shallower waters than those usually sampled in surveys surveying the Gulf of Cadiz shelf (both Spanish and Portuguese surveys). Sampling schemes aiming to solve this problem with the conventional vertical acoustics has been previously described by Guillard and Lebourges (1998), Guennégan *et al.* (2004), and Brehmer *et al.* (2006), amongst others.

5.- CONCLUSIONS

The waters of the Division IXa (Atlantic façade of the Iberian Peninsula and Gulf of Cádiz) show a high diversity of pelagic fish species, in comparison with other pelagic assemblages of northern European waters. Although sardine and anchovy can be considered as dominant species in some specific areas, in most places they appear in conjunction with other species, in some cases being outnumbered by those species. Anchovy distribution in the Division is mainly confined to one defined area in the Gulf of Cádiz, with the distribution of the biggest individuals delimiting the external limits (offshore limit and geographical limits) of the distribution in this area. A persistent but secondary spot of anchovy occurrence is also found in recent years in front of Lisbon. In 2008, new although residual and scattered nuclei of anchovy density have been observed in the northernmost waters as a probable consequence of favourable environmental conditions.

The situation of the anchovy population extracted from the acoustic surveys is as follows: anchovy in Division IXa and specially Gulf of Cádiz anchovy show in comparison to the Bay of Biscay anchovy a better perspective from the different acoustic estimates available (IPIMAR and IEO) and from the observed distribution of eggs (from CUFES). Spring acoustic surveys from IPIMAR and IEO in 2007 provided relatively close biomass estimates (40,000 t and 29,000 t respectively, although the later one is only for the Subarea IXa-S), and a similar spatial distribution of the stock (mainly located in the Spanish waters of the Gulf). These estimates seems to indicate: (a) a slight increase in 2007 in relation to previous years, (b) such increase is still maintained in 2008 (40,000 t), although supported by a lower population number than in the preceeding year, (c) such biomass vs abundance relationship in 2008 suggests an increased mean size in the spawning population probably related with a more feeble year class and the maintaining of the population by the larger (-older) fish.

The distribution of eggs in 2007 also showed a large coverage, although DEPM based SSB estimates will not be available until late 2008/2009, from the survey that will be carried out in 2008. For the previous DEPM estimate, the value (14,219 tonnes in 2005) was also coincident with the Portuguese acoustic estimation (14,041 tonnes); therefore fishery independent SSB estimates seem to provide a coherent view in this area. Nevertheless, the time series of DEPM survey reduces to just one year and therefore proper comparison are yet meaningless, and some differences between the IPIMAR and IEO acoustic estimates have appeared in the recent past.

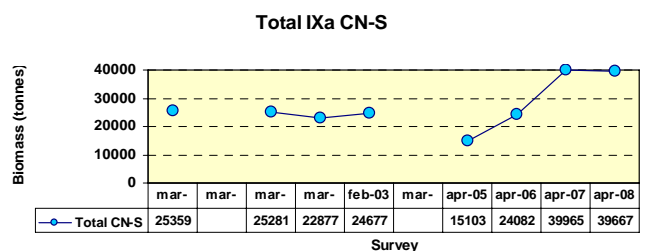
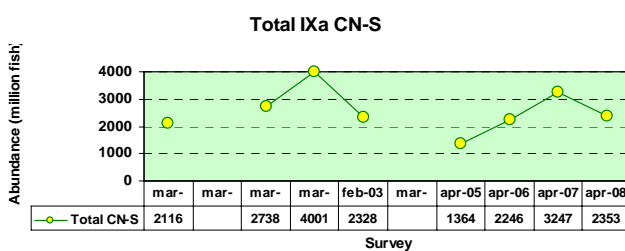
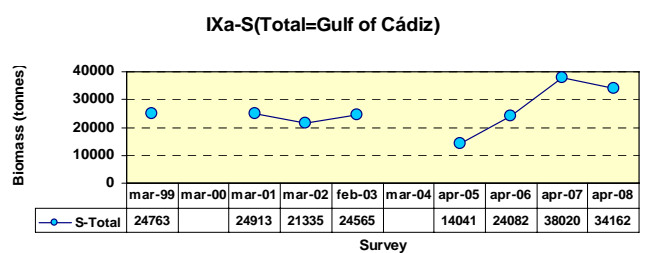
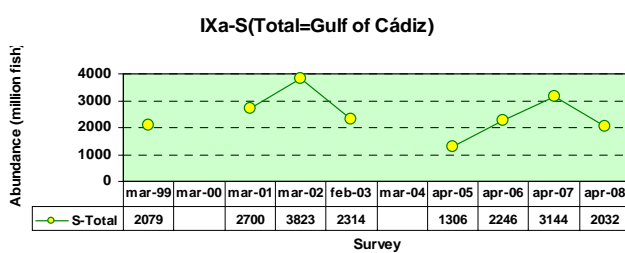
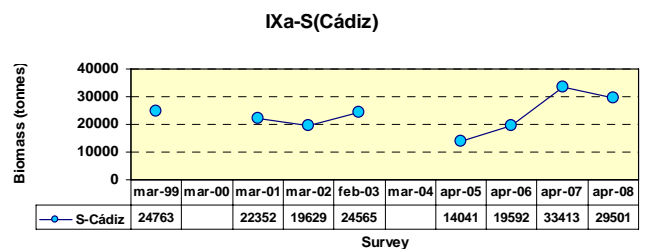
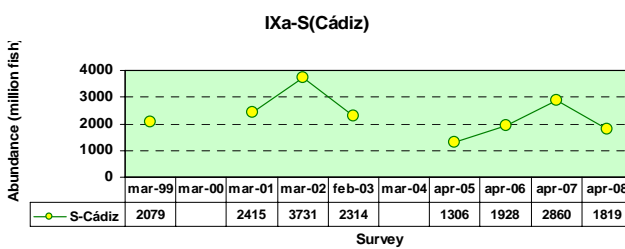
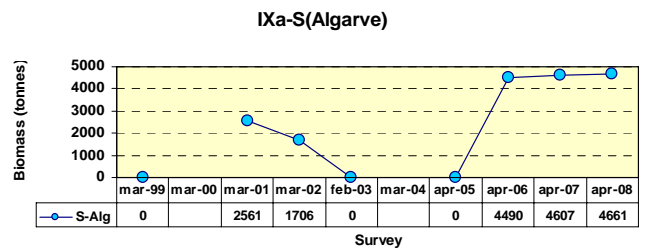
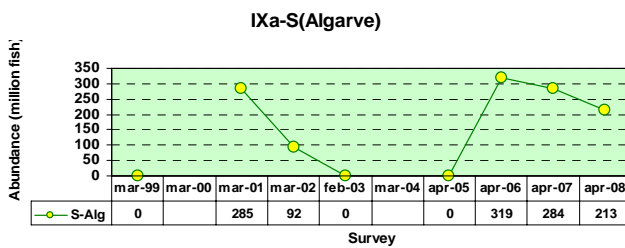
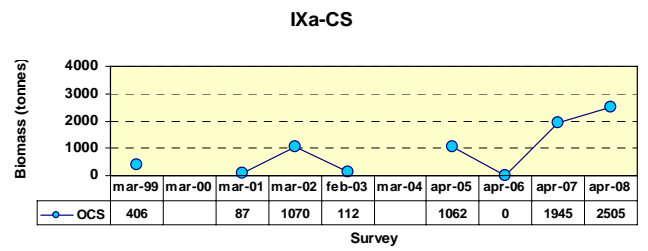
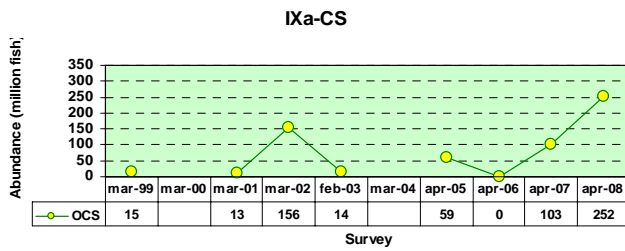
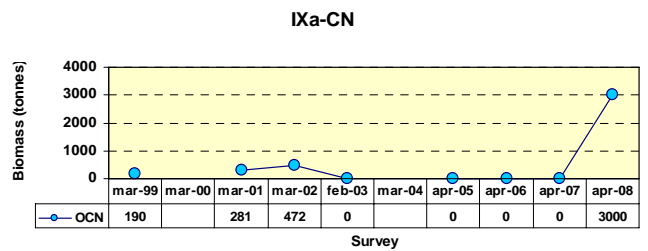
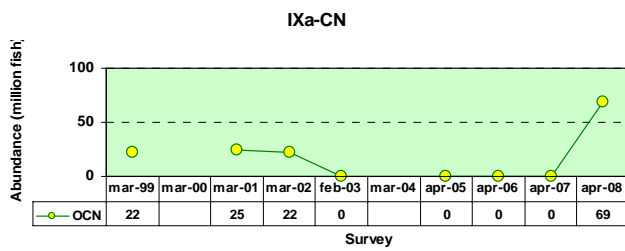


Figure 14. Historical series of anchovy acoustic estimates (abundance in million fish, biomass in tonnes) from Spring Portuguese surveys in the Division IXa. Note the different scale on the y-axis (source: ICES, 2007 b and Vitor Marques, IPIMAR; pers. comm.).

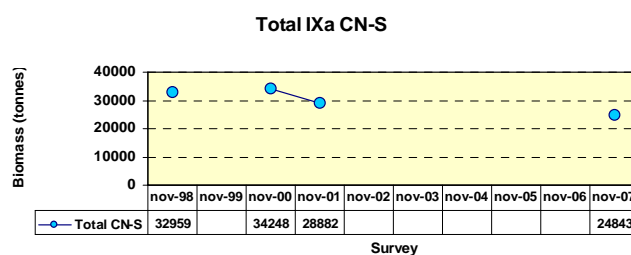
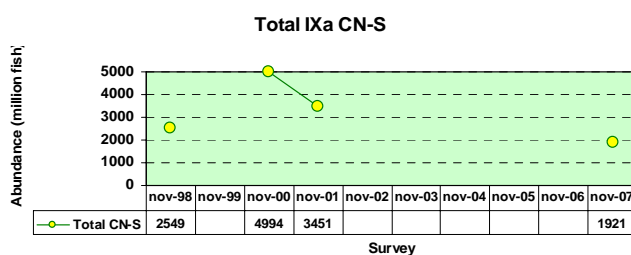
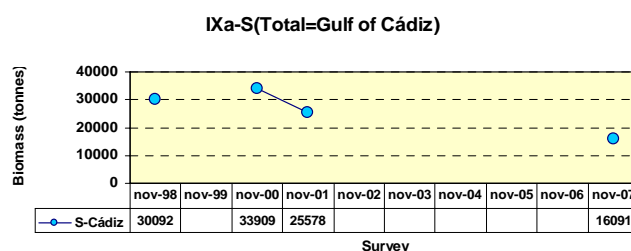
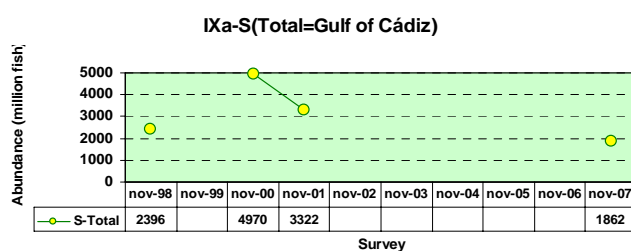
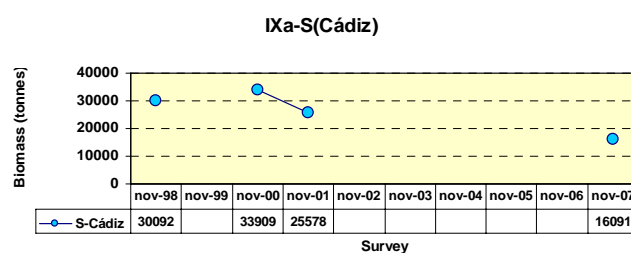
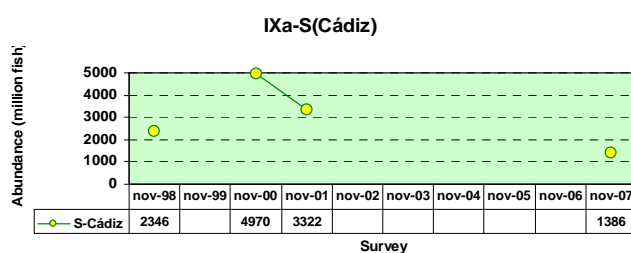
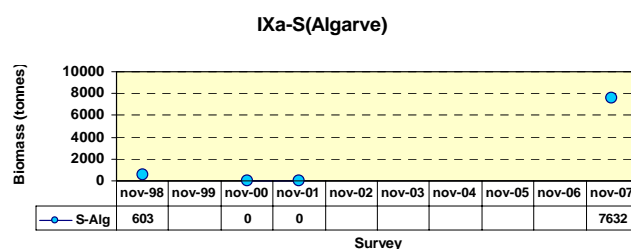
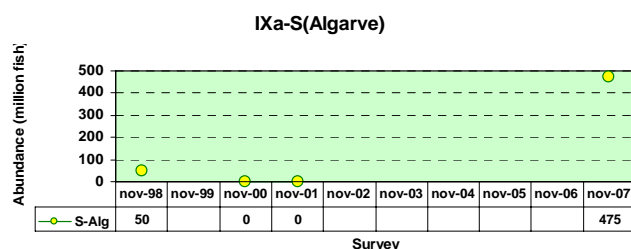
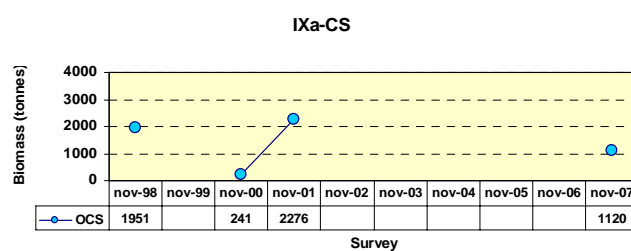
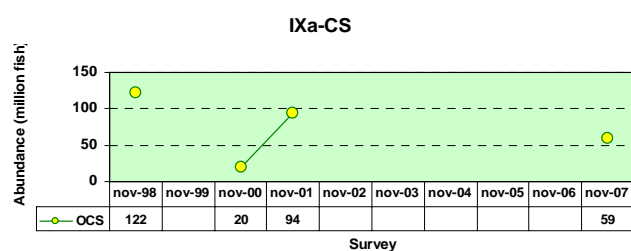
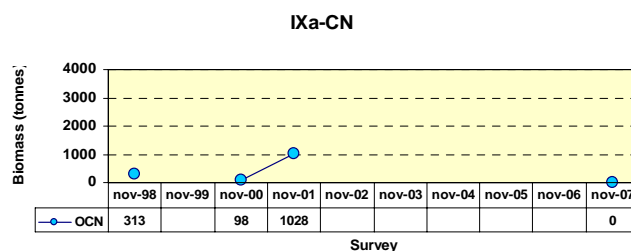
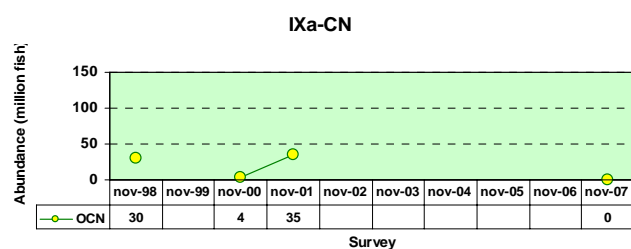


Figure 15. Historical series of anchovy acoustic estimates (abundance in million fish, biomass in tonnes) from Autumn Portuguese surveys in the Division IXa. Note the different scale on the y-axis (source: ICES, 2007 b and Vitor Marques, IPIMAR; pers. comm.).

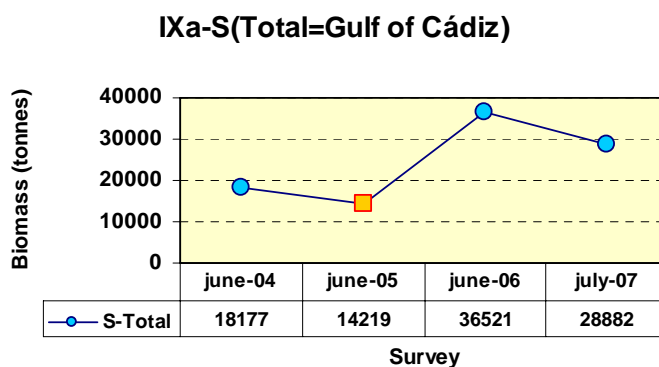
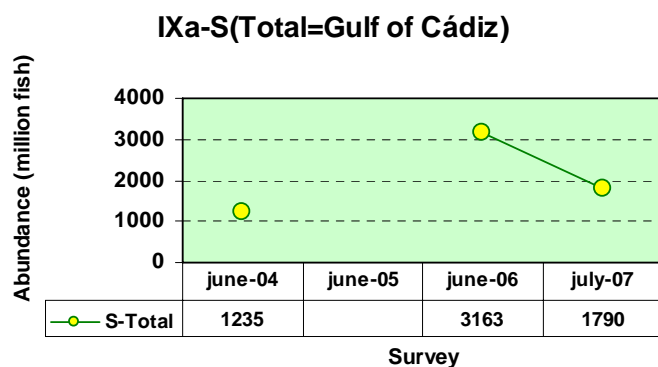
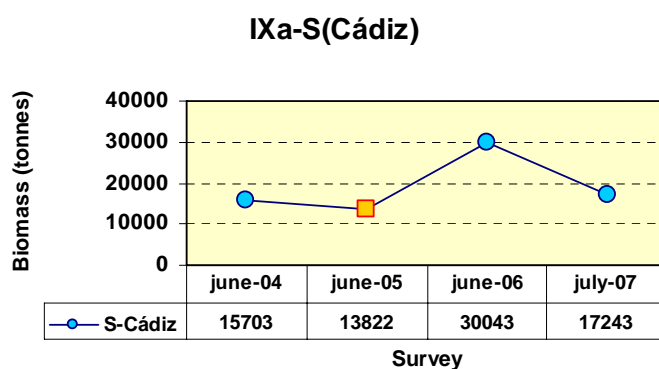
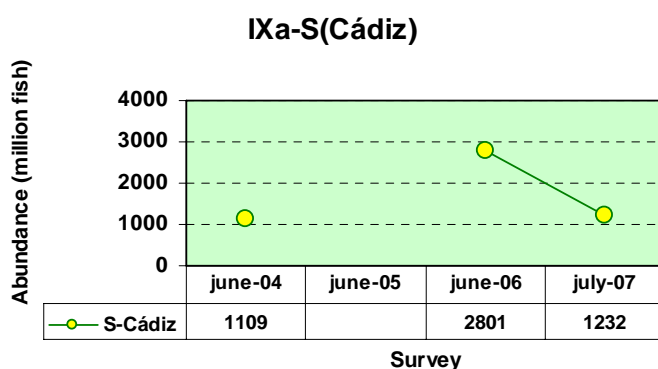
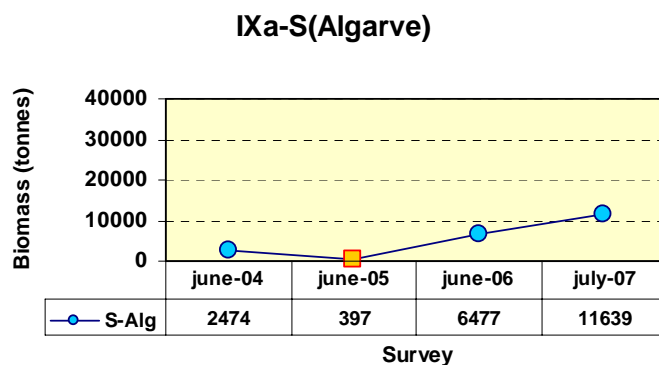
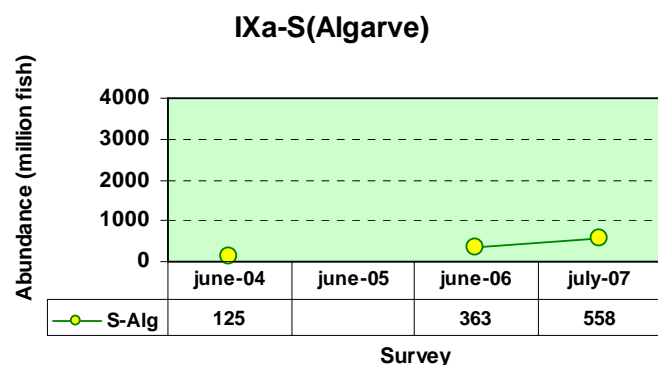


Figure 16. Historical series of anchovy acoustic estimates (abundance in million fish, biomass in tonnes) from Summer Spanish surveys in the Subarea IXa-South. 2004 estimates are pending of further revision (application of recent IEO standards in the estimation process: delimitation of post-strata, increased number of assessed species, species-specific TS, etc). 2005 estimates correspond to those from the anchovy DEPM survey (depicted by a different symbol and color). 2006 and 2007 acoustic estimates are revised (or corrected) ones after application of the new IEO-WGACEEG standards. (Note the different scale on the y-axis (source: ICES, 2007 b).

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